SECTION 2

The Wireless Communications Environment

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The Wireless Communications Environment

Description of the internal and external wireless communications environment and analysis of how these factors affect Nebraska's Public Safety radio options.

Complex communications systems develop in an environment made up of many factors. This environment must be understood before any specific functional or technical design requirements can be considered. Within Nebraska, key concerns include the priorities of state and local public safety organizations, their many different existing systems, local and state level management practices, demographic and public policy factors, and various laws and regulations. Externally, federal policies and the technology marketplace affect Nebraska's options, and the experiences of other states can offer useful lessons. Especially important are the six adjacent states, whose wireless systems overlap Nebraska's borders, and with whom coordinated public safety responses are often carried out.

Nebraska's Public Safety Wireless Community

The public safety wireless community is multi-layered, including government, volunteer, and private entities. The government agencies considered in this study—including federal, state, local and political subdivisions—are those whose missions necessitate using wireless communications or regulating or coordinating such communications. Private entities include radio manufacturers and communications service providers. These relationships are illustrated in Figure 2 on the next page.

Relevant distinctions can also be made among local, area, regional, and statewide systems, as illustrated in Figure 1.

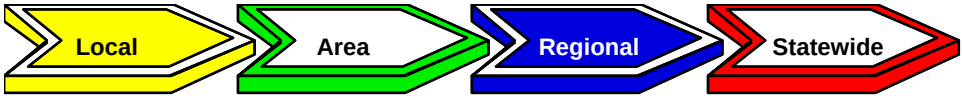


Figure 1: Local, Area, Regional, and State Systems

For the purposes of this discussion, these levels of radio systems are defined as follows:

- Local systems are individual local user systems, such as a single police department, sheriff's office, or fire department.
- Area systems are self-defined cooperating groups of two or more local agencies; they may be any size from sub-county to multiple counties in scope.
- Regional systems are large areas with a significant, *i.e.* over 15%, segment of the state. In Nebraska, state agency districts are regional systems.
- Statewide systems are border-to-border in terms of radio—they allow a radio user to communicate with another user anywhere in the state. As later discussions show, Nebraska currently has no statewide system as defined.

The discussions in this Section summarize the *current* status of key state and local systems. Interoperability across these levels will be explored further in Section 3 of this Plan. Area and regional concepts are also used as building blocks in the system design presented in Section 4.

Figure 2 is a diagram that outlines the whole public safety wireless community. Entities that were directly not directly involved in this study are shown in lighter print.

Figure 2: The Public Safety Wireless Community

Radio Spectrum Frequency Use

Throughout this Plan, many references are made to public safety radio **frequency bands**. A brief explanation of the terms used in these discussions may be useful for some readers.

Electromagnetic Spectrum: The complete range of all possible frequencies, measured in units called Hertz (Hz).

Frequencies range from the very low range of ordinary household current (60Hz), through the audible sound range (20Hz to 16KHz) and the radio range (various segments between 30KHz to 30,000 MHz), to visible light spectrum and higher.

All wireless communications systems operate within specific parts of the **electromagnetic spectrum**. Each specific segment of this spectrum is called a **frequency** and is expressed in cycles per second, or megahertz, and is abbreviated MHz. Because the radio spectrum contains a limited number of frequencies, they must be shared among many users and many types of systems—broadcast radio and television, mobile radio and cellular, air navigation, commercial, government and military.[1]

The needs of public safety agencies for land mobile radio frequencies are protected by being allocated use of frequencies in the specific bands as shown on the diagram below.

VLF: Very low freq.
LF: Low frequency
MF: Medium freq.
HF: High Frequency
VHF: Very high freq.
UHF: Ultra high freq.
SHF: Super high freq.
EHF: Extra high freq.

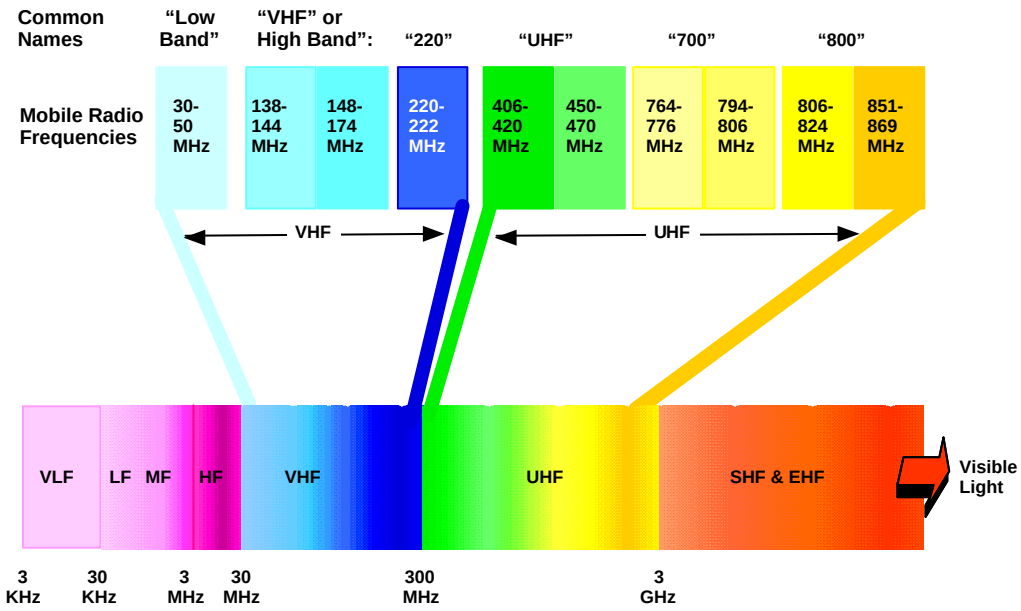


Figure 3: Part of the Electromagnetic Spectrum Showing Mobile Radio Segments

Nebraska public safety agencies have radio systems in four frequency bands: low-band, VHF (high band), UHF, and 800 MHz. The 220 MHz and 700 MHz bands were recently allocated for public safety systems by the Federal Communications Commission, but little or no use is being made of them as yet. Later Sections of this Plan will discuss in detail the use of frequencies and the technical characteristics of

[1] For example, the frequency allocated to the Nebraska Public Radio station in Chadron is 91.9 MHz.

radio systems in these frequency bands. For the present purpose, note that the four frequency bands are generally used in Nebraska in the following ways:

- Low-band is currently used in several different ways:
    - As the primary system for several state agencies, who must supplement it in order to be able to talk to other frequency band users;
    - For mutual aid, primarily using the general frequency 39.9 MHz;
    - As the primary system for many local agencies (including 47%[2] of those who responded to the survey for this study), many of whom use 39.9 MHz and know it as their "Sheriff's Channel";
    - As the (often only) radio available to small local agencies, especially fire departments via the "fire frequency," and therefore also carried by any agency needing to communicate with the fire or rescue units; and
    - As a backup system for local agencies who have migrated to newer technologies but who still need to talk to the State Patrol and other low-band users.

    The so-called mutual aid channel is actually no longer an effective means for agencies to intercommunicate. Increasing numbers of agencies who have migrated to other frequency bands do not have ready access to 39.9 MHz. Even when they have retained their low-band radios, because they do not use the mutual aid channel regularly, they tend to turn it off or keep the volume low so that it does not distract them from their primary channels.

Mutual Aid frequency: A frequency licensed over a wide area by many different users. All licensed users can make use of the frequency if it is included on their radios and they are within range of a transmitter.

- High band is the primary frequency for most federal agencies and Tribal Governments, the Game and Parks Commission, and 24% of the local agencies around the state that responded to the survey for this study.
- UHF is used as a primary band by NEMA and by a total of 22% of local agencies that responded to the survey for this study, including a growing number of EMS providers.
- 800 MHz is used by most public safety agencies in Sarpy, Lancaster, and Buffalo Counties, and 18% of those who responded to the survey for this

[2] Many agencies reported using more than one frequency band. For the 148 total responses from local agencies, 249 individual radio systems were reported. The percentages shown in this list are of the total systems, rather than total agencies.

study. A few additional agencies have at least one radio in this frequency band for interoperability. Several local agencies are considering system conversions to this band. Commercial 800 MHz radio service providers are also available in some areas of the state.

Nebraska State and Regional Systems

Although this study is concerned with all public safety agencies, it is notable that some of the agencies with the oldest and most limited radio systems have statewide missions that especially require interoperability. This is particularly true for state law enforcement functions, which are centered in the Nebraska State Patrol, the Law Enforcement Division of Game & Parks, the prisoner transport function of Correctional Services, and the State Fire Marshal Inspection and Investigation staffs.

State Agency Systems

The information that follows summarizes briefly the existing systems in use by major state agencies with public safety missions.

Nebraska State Patrol (NSP)

"You go out there now in Patrol and police cars—you're going to find three radios or more, and probably a couple of other devices including a cellular phone and a scanner…and it doesn't work well.

The more rural the area, the later it is at night, the more the public safety folks depend on each other…The State Patrol can't communicate from car to car half the time. That's crazy! Clearly there's a need."
—Alan Curtis, Crime Commission Director

The two primary law enforcement functions of the State Patrol are highway vehicle and motor carrier enforcement. The agency also performs investigations and assists local law enforcement agencies upon request. Although routine operations focus along federal and state highways, NSP officers may operate anywhere in the state.

The agency's radio system operates in the 42 MHz (low-band) range. Six frequencies are deployed statewide. Each of the six troop areas uses two of these frequencies, and frequencies must be assigned so they are not repeated in contiguous troop areas. The system operates in simplex mode, with no repeaters. This means that each frequency can be used either for transmitting or receiving, but not both at the same time. NSP uses these frequencies in pairs, one for transmitting, and one for receiving.

Direct vehicle-to-vehicle communications require supplementing the low-band radios with secondary portable UHF radios. These portables work use repeaters carried in the Patrol vehicles. They can communicate only with other mobiles and portables that are within a limited distance of their mobile repeaters.

In addition, some patrol vehicles or officers also carry radios provided by local agencies with whom they regularly need to communicate but who use different frequency bands. An example is the 800MHz radios carried by the patrol officer(s) in the Lancaster County area whenever there is an event that calls for joint action. Where local agencies do not use low-band radios, messages from NSP vehicles must be relayed through one or more dispatchers.

All Patrol low-band mobile radios for each of the troop areas (590 total units) are dispatched from their respective troop area headquarters. Three additional VHF low-band frequencies are used for simplex vehicle-to-vehicle traffic as well, and four more are used by Patrol investigators. Most radios are over ten years old and in need of replacement. Current systems do not support provide secure communications.

Neither Highway Patrol nor Carrier Enforcement vehicles use wireless data transmission at present. A pilot study tested wireless data using an analog 800MHz commercial cellular service. The test was not completely successful; reliability rates in one of the trial areas were reported to be as low as 10%.[3] As of early 2000, about 25-30 carrier enforcement personnel have been equipped with laptop computers that are used in their vehicles, but these are not able to transmit data over a wireless connection. File transfers are performed by physically taking the laptop to a location where a desktop unit or network connection is available. Automatic Vehicle Location (AVL) would be a valuable tool for law enforcement and management, but is not deployed for the agency.

Automatic Vehicle Location (AVL): a capability that integrates wireless communications with satellite tracking to pinpoint the exact location of a vehicle.

NSP has a fleet of four fixed-wing aircraft and one helicopter. These are equipped with low-band radios as well as aircraft radios (which are in their own frequency band).

Nebraska Game and Parks Commission (G&P)

Game and Parks has law enforcement jurisdiction in all state parks, recreation areas and trails, historical parks, game refuges, fish hatcheries, rivers, and wildlife management areas. Because of this diversity, most operations occur within in a large number of discrete sites around the state, rather than continuously across the landscape. Not surprisingly, many of these sites are in remote areas where G&P is often the only agency present. The agency provides a wide range of services in all these areas, as well as primary response along the waterways in and bordering the state. Much of the agency's radio use is internal with respect to each site or cluster of sites.

The agency's radio system operates in the VHF high band. This system uses one repeater channel consisting of two frequencies, plus five mobile frequencies, for most of the agency's communications. Law enforcement vehicles also carry VHF low-band mobiles in order to communicate with NSP and some local agencies. Radio equipment is generally old—much of it dating from the 1970s—and has been minimally maintained in recent years pending the development of a state wireless plan. VHF portable radios, of which the agency has about 300, have limited access to the system repeaters due to obsolescence. A few low-band portables are also in use.

Some Game and Parks vehicles also carry scanners that cover low-band, high band, and UHF. This permits at least partial ability to hear communications on other bands.

[3] The technology being used is known as Cellular Digital Packet Data or CDPD. This technology is being used successfully in other parts of the country.

However, in order to talk back officers must radio a dispatcher, who must then relay the message. More than one dispatcher may need to be involved. Typical Law Enforcement Division vehicles, which may operate statewide, have both low-band and high band mobiles plus at least one portable. Wildlife, Fisheries, and Parks vehicles normally have only one mobile. Officers may or may not have a portable as well. G&P does not currently have the capability for mobile data, AVL, or secure communications.

Nebraska Department of Correctional Services (DCS)

DCS' mission encompasses the operation of all state correctional facilities and related programs, the state's adult parole system, and the transport of inmates to and from state facilities. The bulk of the department's responsibilities center on the institutions, each of which uses one or two radio systems for internal custody and maintenance functions. However, the present study focuses primarily on inmate transport, which takes place outside these fixed sites. DCS does not have its own wide area radio system but uses a combination of mutual aid frequencies and commercial services. Unification of all these diverse systems would be more productive and efficient for the agency as a whole, as well as supporting needed interoperability with others.

Inmate transports are most commonly either from one state facility to another or from a facility to a work site.[4]

- Work site transport is done by passenger vans. In the Lincoln area, vans use commercial 800MHz radios. As long as they remain within the service area of the commercial provider, these radios work well. Similar services are not available at other state institution sites.

- Transport between institutions is more difficult. Vehicles are equipped with low-band radios using the statewide mutual aid frequency (39.9 MHz). These radios can only communicate when the vehicle is in range of a local Sheriff's Department or other agency listening to this frequency.[5]. Low-band equipment is old and does not provide service in all areas. As a stopgap alternative, transport vehicles have been using cellular telephones almost universally.

[4] In some cases, DCS transports inmates to and from city or county facilities, although more often this is done by the Sheriff's Departments.

[5] One recurring theme regarding the low-band mutual aid frequency is that agencies not using it regularly tend to turn it off or lower the volume much of the time.

Parole officers do not have direct radio contact with local law enforcement.[6] They rely on cellular telephones to remain in contact with their offices when in the field, and as a safety device on the frequent occasions when they work in unsafe areas. Again, these are used as a temporary measure pending a statewide plan for radio. Cellular signals are not ideal for safety purposes, since they may not be available when needed.

Currently, there is no wireless data, automatic vehicle location (AVL), or communications security functionality deployed for Correctional Services.

Finally, paging is an important communications tool for DCS, particularly for tracking the locations of employees in the field. Currently, the department does not have its own paging system and instead uses a patchwork of local commercial paging services.

Nebraska State Fire Marshal's Office (SFM)

A field staff of 43 is responsible for statewide fire standards, rules, training, and reporting. The agency also responds to most fatality and arson fires, and investigates or assists local departments to investigate all fires. Currently it responds to highway accidents, industrial accidents, and other fires that may involve hazardous materials. In addition, the agency performs regular fire inspections and licenses fireworks use.

SFM uses low-band mobile radios in field vehicles, plus mobile VHF (high band) repeaters and portables. Three low-band frequencies are in use: 39.9 MHz (the statewide "mutual aid" frequency, 39.98 (also known as the statewide "fire frequency"), and 39.66 MHz (a mobile-only frequency shared with NSP and used primarily for working with them). Officers have no portable communications with NSP or most local agencies.

"We currently have no means to contact field personnel by radio, pager or cell phone. The cost of having all 43 of our field staff provided with cell phones—the closest thing we have to statewide coverage for communications—is prohibitive.

We all have radios so that we may communicate in our regions with those who are on the same frequency, but that number is getting smaller and smaller."

—Ken Winters, State Fire Marshal

"Valentine does not have a fire inspector, so we are their fire investigators. We need to be able to communicate with them…and with local law enforcement wherever we are. When a fire department responds to a fire—it doesn't matter, day or night—they call back to their dispatch, generally a sheriff's office, then *they* contact a deputy by telephone or pager or radio to say that the fire department is requesting a response from our agency. Only then do we get the call."—Fire Marshal's Office

[6] The Intensive Supervision program in the agency is beginning to use Electronic Monitoring of parolees. Currently, this is limited to Douglas and Sarpy Counties. These services are leased from a commercial provider; their cost is significant and has limited the use of this technology.

In order to contact staff in the field, the agency uses a combination of commercial paging services in lieu of radio coverage. No wireless data or other advanced features are currently deployed.

Nebraska Health & Human Services System, Emergency Medical Services Program (State EMS)

This small group within HHSS plays a key coordinating role among the hundreds of EMS services around the state and the hospitals and trauma centers they connect with. For their own use, they have installed VHF low-band radios to maximize the possibility of communications with fire, EMS and other local and state agencies. Their low-band radios connect them with fewer and fewer agencies as these agencies migrate to other frequency bands. Staff also use cellular phones. Since emergency medical service provision is essentially a local public safety function, it will be treated more fully in the next section, Local and Area Systems.

Nebraska Department of Roads (NDOR)

NDOR's mission is to plan, design, finance, construct, and maintain the state highway system. This large agency has employees from engineers to snowplow or mower drivers in the field every day. It cooperates with law enforcement and public safety agencies in responding to highway-related and other incidents. For these reasons, the agency characterizes its entire mission as public safety related.

Construction and Maintenance divisions are the primary users of wireless communications. Each of the agency's eight districts has its own low-band radio system. In total the agency uses nearly 3000 mobile radios, making it the largest state user of radios by a substantial margin.[7] UHF vehicular repeaters and portables are also deployed in about one out of every four vehicles, and a similar number of cellular phones are in use as well. Frequencies in use are in the 47 MHz range, and existing systems operate in simplex mode.

Most of the current equipment is in good condition and eight years old or less. The Department follows a regular replacement schedule so that the entire system remains fully operational.

Military Department

The Military Department is the umbrella agency that includes both the Nebraska Emergency Management Administration (NEMA), and the Army and Air National Guard units. NEMA plays a significant role in emergencies and disasters of all types, and is the first responder in case of nuclear power plant incidents. The Guard is a first

[7] It is not known how the size of this system compares to the largest local users, since no law enforcement agencies in Douglas, Sarpy, and Lancaster Counties submitted survey responses for this study.

responder for hazardous materials risks connected to highway, railroad or aircraft accidents involving federal vehicles. The Air Guard also has responsibility for fire safety at the Lincoln airport where their base is located.

When NEMA becomes active in a disaster on request from a local government agency, its primary mission is to facilitate coordination among all the responding agencies. Because of its primary communications mission, NEMA tries to use a variety of different radios to maximize the probability of being able to communicate with other agencies. The agency's own radio system operates on UHF mid-band, with the addition of various VHF low-band frequencies for interoperability.

> "We have a need to communicate with every agency in the state, especially during disaster recovery. We had a flood up in Platte Center. The people in the county and the city couldn't talk because they didn't really have a radio system. The mayor was trying to get hold of the village board members…the phones were out…we went out there with our mobile van and set up a repeater and checked out handheld radios.
>
> —Bob Eastwood
> NEMA

During disasters, NEMA has the ability to take programmable radios to the site for the use of the on-site commander, or to create a temporary common communications channel for key people at an emergency site. The agency also makes extensive use of ham (amateur) operators.

NEMA staff coordinates with emergency managers (EMs) in each Nebraska county. Many of these county EMs have other responsibilities and use whatever radios they have for other purposes. For example, it is common for an EM who is also a firefighter to use his or her fire department radio—most often a VHF low-band unit—for emergencies of all types. NEMA also uses commercial cellular services where available and satellite radios supplied by the Federal Emergency Management Administration (FEMA).

Army National Guard is activated for disaster response by the Governor, and the Air Guard may be called in after that. When either unit is called out, it offers whatever equipment or assistance it can to NEMA and usually joins NEMA at the scene.

For their own purposes, these two Guard units use military high frequency (HF) and VHF high band radios. These systems are designed to support only internal Guard functions, however, and are not available to others. In disasters, the Air National Guard has a supply of programmable mobile and portable radios that can be deployed to all agencies at a site.

The Military Department currently has no wireless data capability. The Air Guard disaster preparedness team, which provides first response unit for hazardous materials incidents, has a wireless local area network that can be set up at a site to communicate among personnel in the field. If there is telephone service available, the team can also communicate on a dial-up basis with the headquarters data network.

Figure 4 on the next page is a chart summarizing quantities of subscriber units and base stations for the major state agencies discussed above.

Summary of Current State Systems

Radio quantities for the state agencies discussed are shown below. A few UHF 800 MHz radios are also available through purchase or loan.

	Low-band (VHF)		VHF (High Band)		UHF	
NSP	Mobiles	590	Mobiles	0	Mobiles	0
	Portables	0	Portables	0	Portables	505
	Base Stations	40	Base Stations	0	Base Stations	0
G&P	Mobiles	100	Mobiles	450	Mobiles	0
	Portables	20	Portables	300	Portables	0
	Base Stations	0	Base Stations	28	Base Stations	0
DCS	Mobiles	NR[8]	Mobiles	NR	Mobiles	NR
	Portables	NR	Portables	NR	Portables	NR
	Base Stations	NR	Base Stations	NR	Base Stations	NR
SFM	Mobiles	49	Mobiles	49	Mobiles	0
	Portables	45	Portables	54	Portables	0
	Base Stations	3	Base Stations	0	Base Stations	0
EMS	Mobiles	6	Mobiles	2	Mobiles	0
	Portables	6	Portables	4	Portables	0
	Base Stations	0	Base Stations	1	Base Stations	0
NDOR	Mobiles	2,941	Mobiles	0	Mobiles	0
	Portables	158	Portables	0	Portables	328
	Base Stations	29	Base Stations	0	Base Stations	29
NEMA	Mobiles	NR	Mobiles	NR	Mobiles	NR
	Portables	NR	Portables	NR	Portables	NR
	Base Stations	NR	Base Stations	NR	Base Stations	NR
Totals	Mobiles	3,686	Mobiles	501	Mobiles	0
	Portables	229	Portables	358	Portables	835
	Base Stations	72	Base Stations	29	Base Stations	29

Figure 4: Public Safety Radio Quantities for Selected Sate Agencies

[8] Not reported.

Interagency Asset Sharing

Radio systems used by state agencies developed historically as separate systems, each serving primarily internal functions. Low-band is the most prevalent system still in use by state agencies. The initial deployment of low-band was intended to serve a statewide intercommunication function. As noted earlier, a mutual aid frequency also known as the Sheriff's Channel and a state fire frequency were made available for licensing across the state. Many local jurisdictions, especially fire and rescue departments, still use these channels for their primary requirements.

When possible, state agencies co-locate their transmission antennas and related equipment on the same physical towers, many of which are owned by the state. Generally, they do not share district boundaries, radio base stations, or dispatching. Tower sites and districts are discussed below.

State Tower Sites

Communications tower sites are owned by four state agencies: NSP, G&P, and NDOR, (the three public safety agencies that have statewide radio systems) plus Nebraska Educational Television Network (NETV), which uses towers for its public radio and televisions transmitters and translators. In some cases, these state towers provide antenna space for other local or federal agencies as well.

- NSP owns ten tower sites and occupies another 28. Most are 300 feet tall. Two new tower locations are being brought into service in the near future to cover existing gaps in service.

- Game and Parks owns two towers but has 16 repeater locations and control points, on towers ranging from 300 to 1200 feet in height.

- Roads owns 28 towers, and occupies leased space on an additional ten towers owned by others.

In addition, public safety agencies lease space on several towers owned by other public or private entities. The table on the next page shows the location of all tower sites owned by the state and leased by public safety agencies.

This is a subset of a more detailed tower inventory prepared as part of this project, which includes sites owned by various public power districts, wireless service provider, and others. The larger inventory was used in technical design and radio propagation studies. The detailed inventory includes latitude, longitude, height above ground level, and elevation of the site above mean sea level.

Location	Owner	NSP	DOR	G&P	Location	Owner	NSP	DOR	G&P
Ainsworth	Leased	√			McCook	NSP	√	√	
Alliance	Leased			√	Merriman	NDOR		√	
Angora	NDOR		√		Merriman	NETV		√	√
Angora	NETV			√	Mullen	NDOR		√	
Arnold	Leased	√			Neligh	NDOR	√	√	
Arthur	GNP			√	Niobrara	NDOR	√	√	
Atlanta	NETV				Norfolk	Leased			√
Auburn	NDOR	√	√	√	Norfolk	NSP	√		
Axtell	Leased			√	North Platte	Leased			√
Ayr	NDOR	√	√		North Platte	NDOR		√	
Bassett	NDOR		√		North Platte	NSP	√		
Bassett	NETV		√	√	O'Neill	Leased			√
Beatrice	NDOR	√	√		O'Neill	NDOR	√	√	
Beatrice	NETV				Ogallala	Leased	√		
Beaver X.	Leased	√	√	√	Ogallala	NDOR		√	
Benkelman	Leased	√			Omaha	NETV			
Bertrand	NDOR		√		Omaha (11th)	NSP	√	√	
Blair	GNP			√	Omaha (16th)	Leased	√		
Broken B.	Leased		√	√	Ord	Leased	√		
Carroll	NETV	√	√	√	Ord	NDOR		√	
Chadron	NETV				Oshkosh	NSP	√		
Chadron	NPPD			√	Pawnee City	NETV			
Cozad	Leased	√			Phillips	NDOR		√	
Crawford	NDOR	√	√		Platte Center	NDOR	√	√	
Crookston	NDOR	√	√		Pleasanton	Leased		√	
Falls City	NETV				Rushville	NSP	√	√	
Fremont	NDOR		√		Scottsbluff	NDOR		√	
Giltner	NETV				Spencer	Leased	√		
Grand Is.	NSP	√			Sutherland	NETV			
Hayes Ctr.	Leased			√	Tekamah	NSP	√		
Hebron	Leased	√			Thedford	Leased	√		
Holdrege	NSP	√			Tryon	NDOR		√	
Hartington	NDOR	√	√		Wauneta	NDOR	√	√	
Huntsman	NDOR	√	√		Whiteclay	NSP	√		
Ithaca	NETV	√			Whitman	NSP	√	√	
Kearney	Leased	√			Winnebago	NDOR	√	√	
Lincoln	DOR		√		Wolbach	NDOR	√	√	
Lincoln	NSP	√			York	NDOR		√	
Maywood	NDOR		√						

Check marks indicate that the tower is used by the agency noted.

Figure 5: State Owned and Leased Tower Sites

Regional Districts and Dispatching

Each state agency included in this study divides its operations among regional districts. However, the district boundaries, even among divisions in the same agency, match each other approximately at best. On the pages following this section, the district boundaries of each agency are shown on maps of the State.

District offices for state agencies with major radio systems are listed below. The numbers on the chart are the agency's own district numbers.

Location	NSP	G&P	SFM	NDOR
Albion			District 3	
Ainsworth				District 8
Alliance		District I		
Bassett		District II		
Bridgeport				District 5
Grand Island	Troop C			District 4
Kearney		District VI		
Lincoln	NSP HQ	District V	District 1	District 1
McCook				District 7
Norfolk	Troop B	District III		District 3
North Platte	Troop D	District IV	District 2	District 6
Omaha	Troop A			District 2
Scotts Bluff	Troop E			

Figure 6: State Agency District Offices

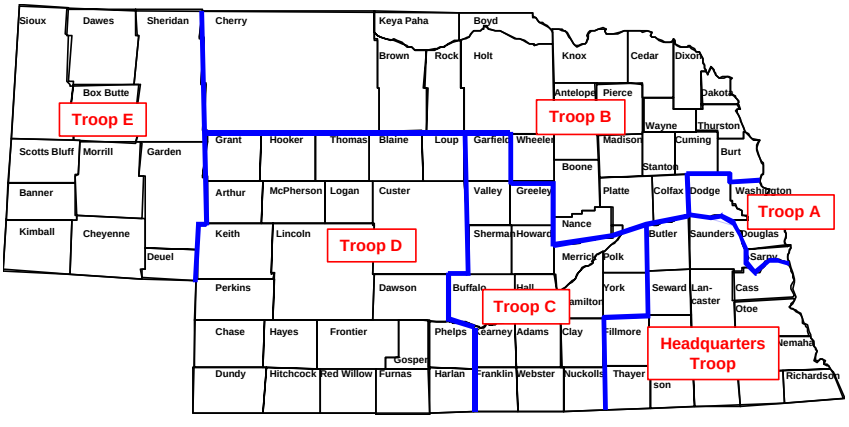


Figure 7: State Patrol Districts

- NSP's dispatching functions for all divisions are performed at their district offices, which are referred to as Troop Areas, plus their main headquarters in Lincoln.

This includes dispatching for the Carrier Enforcement Division, even though that division has different districting.

- Game and Parks: Law Enforcement, Fisheries, Wildlife and State Parks each have their own districts, which do not correspond to each other or to other state agencies. The agency dispatches from many locations among all divisions. A repeater system is used for statewide communications, but much of the agency's radio use is internal to each park and is not dispatched.

- Correctional Services does not have its own statewide radio system or dispatchers. Instead, it relies on dispatch centers in the local areas through which it travels in transporting inmates among facilities, or it uses cellular services if no public safety backup is available.

- Similarly, the State Fire Marshal does not have its own dispatching services, but works through the local Sheriff's or Police Departments, or area emergency communications centers. The SFM divides its staff among three very large territories.

- Finally, NDOR has a single set of district boundaries for all its functions. There are no full-fledged dispatch consoles; instead, field staff are contacted from over a hundred stations located in agency offices, sign shops, and other facilities. The map below, Figure 8, shows the NDOR districts.

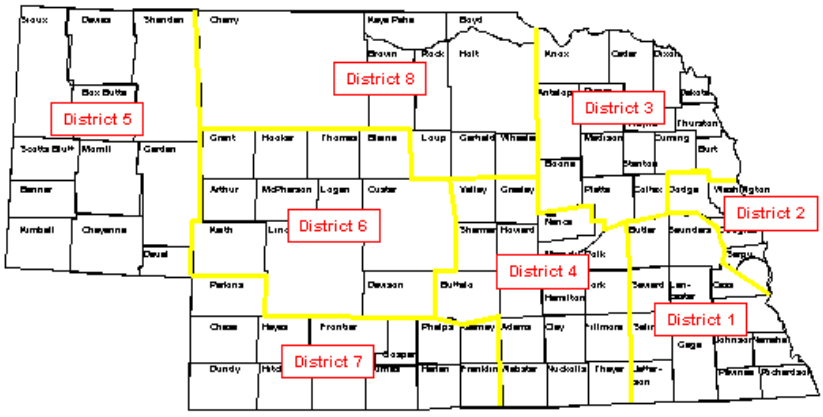


Figure 8: Nebraska Department of Roads Districts

Nebraska Area and Local Systems

> "What I hear is, 'when is the State going to come in and help us with our radios?'"
> —Garry Steele, State EMS

Local agencies surveyed and interviewed for this study are highly interested and concerned about the future of radio communications in Nebraska. Some are most concerned about funding issues, while many others reiterated the need for continued autonomy from State dominance. The majority were skeptical about whether this study would be able to accomplish anything in the Legislature. A fear expressed by one participant and common to many is that "nothing will happen—again!" Nevertheless, many took the time to meet with the consultants to share their ideas and suggestions.

Because so many local agencies have already replaced or upgraded their radio systems independently, there is a substantial knowledge base among local officials. At the same time, since systems were designed for each area's own needs, there is extreme fragmentation, sometimes even within relatively small areas.

Nebraska's public safety agencies are strongly predisposed toward providing mutual aid when needed. While not uncommon in other states, this approach is a notable asset from the standpoint of this study. Communities are quick to point out that most public safety work occurs at the local level, and that local needs should drive statewide coordination efforts. The most successful cooperation will clearly need to arise from shared interests.

Nearly every known type of wireless communications system is deployed somewhere in the state. There are many vintage VHF low-band systems, some originally installed shortly after WWII. It is a testimony to the quality of these systems that they have been able to function during the ensuing decades, although parts and technical expertise are now rapidly disappearing. Many repairs or "upgrades" must rely on used components.

The situation in the Panhandle is a good illustration of conditions all around the state. Reportedly:

- Law enforcement officers in the area are most often on low-band in the nine counties in the area—all Sheriff's Departments have access to the low-band "Sheriff's frequency".

- A consolidated communications center in Scottsbluff dispatches to the police departments in Scottsbluff and Gering, the Scotts Bluff County Sheriff's Department, and many other public safety agencies; these agencies have channels in all the public safety radio frequency bands.

- Nearby Banner and Sheridan Counties have systems in the low-band and 800 MHz ranges (Alliance is the only city in Sheridan County with the latter). Box Butte County uses these plus VHF. Morrill, Dawes and Kimball Counties have only low-band and VHF, while the majority of agencies in remaining counties are primarily low-band only.

- All or nearly all the medical units are using UHF Med Channels (see discussion elsewhere in this Plan), but they also need to carry low-band radios to communicate with other state and local agencies.

- Fire departments in the Panhandle primarily use low-band, but most have at least one 800 MHz radio as well.

Local Law Enforcement Agencies

County sheriff and police departments throughout Nebraska rely heavily upon low-band systems. Arising from an earlier attempt to create statewide radio is the "Sheriff's" or "mutual aid" frequency (39.9 MHz) and other closely grouped frequencies. Many of these low-band radios are also equipped with channels for communicating with both state and other local agencies using low-band. Law enforcement agencies also use VHF high-band, UHF, and 800 MHz systems, often supplemented with cellular telephones. Interestingly, many local law enforcement agencies routinely use cellular telephones to achieve some measure of communications security during sensitive operations. Inexpensive scanners are available that easily receive low-band frequencies, but cellular and PCS transmissions monitoring require a slightly more sophisticated technology.

Among the 43 local law enforcement agencies responding to the survey for this study, almost all the Sheriff's Departments and three-quarters of the Police Departments use low-band. Less than a third of all agencies have only low-band. The majority use more than one frequency band in order to fulfill their regular missions. Counts of law enforcement systems by band are shown on the Figure 9 below.

At a minimum, local agencies—with the possible exception of Douglas County and the City of Omaha—need frequent access to the State Patrol. The most common means for having more than one frequency band are either to use scanners or to have multiple radios in their vehicles.

Frequency Band	Police Dep'ts. Who Use: (22 Respondents)	Sheriff's Dep'ts. Who Use: (21 Respondents)	% of All Respondents
Low-band	16	20	84%
VHF	11	14	58%
UHF	3	4	16%
800 MHz	2	2	9%
Totals	32	40	

Figure 9: Frequency Bands in Use by Local Law Enforcement Agencies

Local Fire and EMS Departments

Local Fire Departments also rely mainly upon VHF low-band (typically 39.98 MHz) for general operations. In some areas, fire vehicles have been equipped with radios capable of operating in other frequency bands to achieve interoperability with other local agencies, as noted above.

Fire departments and rescue units frequently cross county and other borders. Mutual aid agreements are prevalent as a way of amassing enough resources to cover large territories. When adjacent jurisdictions have different radio systems, which is very common, they must sometimes choose which system to use, or carry multiple radios with the attendant costs and inconvenience. Exacerbating this situation is the fact that the majority of fire and rescue departments are staffed by volunteers and have miniscule budgets.

For example, a typical fire department might select UHF for its primary radio system in order to be compatible with the fire department in an adjacent county. It might then also need a low-band system to communicate with other agencies in its own county. If its own county decided to upgrade to a new system in a different frequency band, it would need to consider switching over as well. However, in that case, it would need to be concerned about how to talk to its peers in surrounding counties or about the need for multiple radios. In the end, the investment in radios might approach or even exceed the cost of a truck. This example is very common and illustrates the difficult trade-offs local entities must make.

Figure 10 below is a summary similar to the one provided for the local law enforcement agencies.

Frequency Band	Fire Dep'ts. Who Use (65 Resp.)	EMS Units Who Use (28 Resp.)	Other Locals Who Use (21 Resp.)	% of All Resp.
Low-band	49	21	10	70%
VHF	17	7	9	29%
UHF	29	12	8	43%
800 MHz	29	1	4	12%
Totals	124	41	31	

Figure 10: Frequency Bands in Use by Local Law Enforcement Agencies

"When the hospital went in, they bought a radio for the ambulance, and said, 'here it is, we'll install it, and we'll pay for it.' And they accepted it. "
—Dean Cole
State EMS Director

Nebraska has about 365 individual ambulance services providing at least basic life support. Some 75 to 80% of these are staffed by volunteers, most commonly in combination with the volunteer fire departments. Commercial (private) ambulance services are operating in a number of counties, most often in more populated centers.

In addition, there are mostly private air rescue services strategically located to be able to reach most areas on the state within a short time. Historically, many of these services first obtained radios on whatever frequency was being used by the hospital emergency room they visited most often.

All public safety agencies operate on an emergency mutual aid principle with respect to communities in adjacent states. EMS providers, particularly the private air services, have operating ranges that widely overlap state boundaries.

Both air and ground services perform two functions: trauma support and patient transfers. Trauma cases are those which require emergency rescue service. Typical examples of these cases include highway accidents and medical emergencies such as heart attacks. The majority of trauma cases are handled by ground services. Patient transfers from one facility to another comprise a large part of the providers' workloads as well. Air services most often are used for these purposes.

In 1996, the State EMS office conducted a survey of all ambulance services, to which 232—a significant 64%—of the total 365 services in the state responded. It is reasonable to assume that their answers to survey questions accurately reflect the total population of services.

- Among the respondents, the low-band is the most prevalent frequency band in use; this is not surprising, since ambulances need to connect with other public safety agencies and hospitals, and most of these use the older low-band technology. Where possible, of course, fire and rescue services share low-band systems.

- The next most prevalent is UHF. Many of these systems are of more recent origin. UHF is a good choice for EMS users, since there is a set of UHF frequencies reserved for them[9] by the FCC. In addition, UHF is widely used in aircraft, including the air rescue craft used in Nebraska.

  The UHF system tying together all the EMS users and hospitals in the Panhandle area is often cited as a model for the EMS community statewide. The Panhandle system employs five "Med" channels. The dispatcher in the regional hospital can communicate with all the medical services in the entire area. Services can also be accessed by the consolidated Scotts Bluff County communications center dispatcher. Ambulance radios have simply labeled buttons for reaching dispatch points and other units.

[9] Commonly referred to as the "Med Channels," "Med One," through "Med Ten"; there are many subchannels within this group, and some are used for telemetry or other specialized functions. Channels typically used in Nebraska and elsewhere for ambulance-hospital communications are Med Nine and Ten.

Figure 11 below shows the use of various frequency bands by the ambulance services surveyed.

	Low-band	VHF	UHF	800 MHz	Totals
Number Using	194	60	95	16	
Base Stations	122	22	58	46	248
Mobiles	1000	211	357	160	1728
Portables	546	395	450	300	1551
% Responders Who Use Band	84%	26%	41%	7%	

Figure 11: Ambulance Service Use of Frequency Bands

This summary shows how heavily concentrated the EMS community is in low-band. With a modicum of state assistance, some of the leaders in this community believe they could achieve a uniform implementation statewide.

Area Communications Centers

Nearly every area possesses one or more communications center(s) providing dispatch services to its police, sheriff, fire, and ambulance services, either separately or collectively.

Systems implemented, equipment ages, equipment quantities, dispatch personnel, and personnel training all vary considerably across the state. Some are primitive by current standards, and some are exceptionally well developed. In a number of instances, communication center consolidations among several agencies has been successfully accomplished for economy, efficiency, and coordination of dispatch operations.

A good example of the array of users and frequency bands used in a consolidated dispatch center is Seward County. Seward's center dispatches for all eleven fire departments in the county, the Sheriff's Department, both police departments (Seward and Milford are the only two cities with their own police), and Seward City Utilities, City Sewer, and County Roads. The center also monitors and takes traffic for the State Patrol and Game and Parks. The NSP officer assigned to the area has the Sheriff's frequency added to his low-band radio. Altogether, the center has four low-band frequencies, one high band VHF frequency, one UHF frequency, and one 800 MHz frequency. Paging is done on an additional UHF channel. The center also takes care of the National Weather Service watches and warnings for a three-county area.

Four general levels of development of self-defined area dispatch or communications centers can be distinguished.

- Basic dispatch consolidation involves simply having law enforcement agencies dispatched in common, or having fire and rescue units dispatched from one of the law enforcement centers. Consolidation at least at this level is almost universal.

- Countywide dispatching is an intermediate level, in which all or nearly all of the public safety agencies are dispatched from a single center. This is a very common arrangement in Nebraska. The radio systems themselves are often still separate.

- Multi-county dispatching centers are similar to countywide systems but incorporate users from a larger number of counties, often under the direction of an independent director and user board. Member counties tend to be similar in population, economic base, and other characteristics.

- Integrated dispatching centers may be at the county or larger area level, and include both consolidated radio systems and advanced center technologies.

Self-Defined Communications Areas and Consolidated Dispatch Centers

The Nebraska Emergency Services Communications Association (NESCA) estimates that there are about 90[10] formal local dispatch centers for public safety services in the state. As public safety agencies have recognized the benefits of cooperative efforts, a number of associations among local agencies have arisen. These self-defined areas range from loose inter-local agreements (for example, regarding the use of common radio channels or the procedures to be followed when certain types of events occur) all the way to highly consolidated and technically advanced communications and dispatching centers. Buffalo County and the City of Kearney, along with nearly all other public safety providers in the county, are prime examples of the latter.

Recent years have seen various initiatives encouraging or requiring the development of "911" capability in all areas and "Enhanced 911" (E-911) technology. These initiatives tend to facilitate resource sharing at the dispatch level as well. Many counties have consolidated their Sheriff's Department and one or more local Police and Fire Departments, in order to facilitate 911 dispatching. A funding surcharge on local telephone service partially defrays the costs of the 911 center, although the study found no centers able to rely completely on this funding source. In addition, since many fire departments and volunteer fire and rescue providers have always used the dispatching

[10] This number does not include the many small local "dispatch" points, consisting of a base radio and microphone, that are found in fire departments and many other locations.

services of the local law enforcement agencies, they are often quite open to participating in consolidated systems.

Autonomous and separate law enforcement systems were once able to provide all the public service that was needed. However, in today's environment there are definite advantages to consolidation, provided there are carefully worked out procedures and excellent management and training of dispatchers.

Consolidated systems vary in scope and geographical territory. The map that follows outlines the self-defined areas that were discovered during this study, including both those in full operation and those under consideration. There may be other centers not shown on the map.

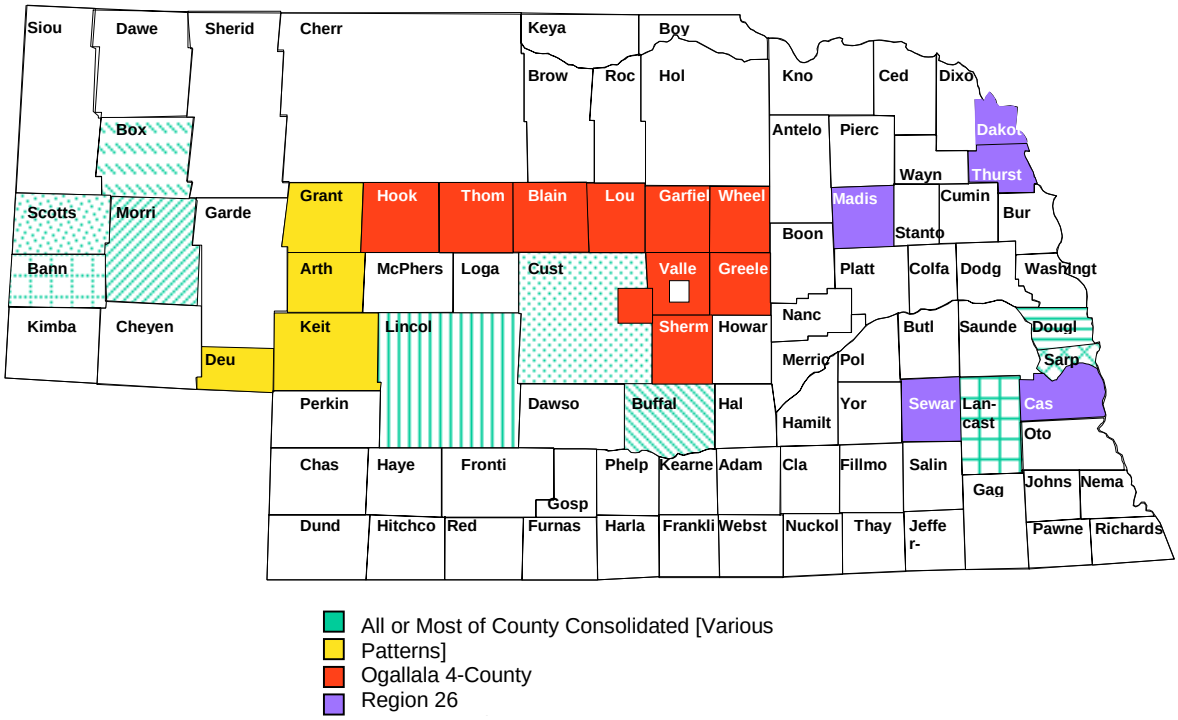


Figure 12: Self-Defined Communications Areas in Nebraska

Every imaginable combination of agencies and territorial extent exists.

- The smallest systems serve only a few agencies in a single small town.
- At the other end of the spectrum is "Region 26," which includes all the agencies in eight counties and parts of two other counties.
- The four counties centered around Ogallala form another multi-county self-defined area.
- Many others serve a single county, such as the recently formed Seward County consolidated 911 center that serves all 17 agencies in its area.

- Other county systems such as the one in Lincoln/Lancaster County serve most but not all the agencies.
- The center planned in Thurston County for 2001 will serve the Omaha and Winnebago tribal governments, but will not replace them.
- Douglas County has a highly sophisticated unified communications center, but the County and City of Omaha have not consolidated their radio systems.

Internal Environmental Factors

Wireless Management in Nebraska

Management of wireless systems in Nebraska is highly decentralized. Each individual state and local public service agency, under the authority of its own governing body, determines its own systems, budgets and operating policies and procedures. Nevertheless, there is a great deal of effort spent in coordination efforts and in some cases, sharing of resources. Training and maintenance are of great concern to the entire Nebraska public safety community.

Statewide Coordination

At the state level, the Division of Communications (DOC) exercises a coordination and oversight role for wireless communications, just as it does for wireline voice, video and data communications. The Radio Communications Section in DOC establishes and manages state contracts for wireless equipment and services, including cellular telephone and paging services. It also coordinates public safety frequency allocations and applications with the FCC. The Radio Communications Manager is also the official state contact point for the Association of Police Communications Officials (APCO). Under FCC[11] delegation, APCO members nationwide perform coordination for most local public safety frequencies. Recently, the DOC was also authorized by the Governor to coordinate the use of State-owned towers by non-state entities.

Also at the state level, the Nebraska Information Technology Commission (NITC) was created in 1998 to develop statewide technology plans and strategies, set standards, and make recommendations on technology investments to the Nebraska Governor and Legislature. NITC also approves grants from two technology funds. One of the three councils established by the NITC coordinates requirements of state agencies, while another coordinates needs of communities.

Coordination among local public safety agencies is one of the roles of several professional public safety groups, which include:

---

[11] Federal Communications Commission, which has final licensing and rule-making authority for radio spectrum allocation and use. Rules for land mobile radio systems used in public safety are found in the Code of Federal Regulations (CFR), Title 47, Part 90 (common carrier services are in Part 22).

- Nebraska Sheriffs Association (NSA)
- Police Officers Association of Nebraska (POAN)
- Professional Firefighters Association
- Volunteer Firefighters Association
- Nebraska Association of Emergency Managers (NAEM)
- Nebraska Emergency Services Communications Association (NESCA)
- Association of Public-Safety Communications Officials (APCO)

Additional statewide associations with a coordinating role include:

- League of Nebraska Municipalities
- Nebraska Association of County Officials (NACO)

Public Safety Wireless Training and Procedures

Operating procedures can be as important a challenge to effective radio communications as the technology itself. Learning to work the radio equipment—for example, what the buttons do and what the call progress tones mean—is relatively straightforward, but the procedures used to operate *efficiently* can be extremely complex. The challenge is analogous to that facing a personal computer user. Today's computers are similar enough so that a minor amount of training can get the user up and running. Becoming an expert user of a specialized software package, however, takes extensive additional training. Radio operating procedures, like high-end software programs, have a steep learning curve. In addition, communications errors and delays can have extremely serious potential consequences, increasing the pressure for accurate and efficient response.

For these reasons, acquiring and keeping up with training and developing operating procedures are major issues for public safety agencies. Even basic public safety communications can be mishandled and cause problems without enough training or with inconsistent procedures. Increasingly, officers find themselves in specialized and complicated situations that involve multiple units, agencies, and procedures.

A simple, common example of the level of inconsistency across the state is the use of "ten codes". These codes have been used for many years as shorthand verbal replacements for frequently needed messages that would otherwise require phrases or sentences. The code "10-4," for example, is a shortcut for "message received" that has migrated into general usage. But in Nebraska, not all agencies use ten codes, and those who do may not use the same codes. Other usage conventions have arisen over time, either *ad hoc* or intentionally, and these may be even less consistent than the codes.

The Nebraska Law Enforcement Training Center (NLETC) in Grand Island, which is a managed by the Crime Commission, offers public safety training for a variety of certification types, from law enforcement to EMS. These programs are supplemented by the offerings of several universities, and colleges. Teaching participants how to use radios is a relatively small part of the curricula of most of these programs. Communications dispatchers most often receive their training from NESCA instructors through a "Telecommunicator Course" offered at NLETC.

Aside from the non-mandatory NLETC course, this study found no standard training or operating procedures in use throughout the state.

Wireless System Maintenance

The Nebraska State Patrol operates a radio maintenance shop in Lincoln that provides service to most of the agency's radio systems. Currently, two contractors (in Scottsbluff and O'Neill) serve remote areas, but these are being phased out and replaced by a second in-house shop located in Ogallala. NDOR has its own electronic repair technicians located in Omaha, Norfolk, Grand Island and North Platte who are responsible for many types of equipment in addition to radios. Additional installation and repair work is outsourced to local vendors.

Other state and local agencies have a variety of arrangements for maintenance. Some are entirely reliant on local vendors, while others, such as the City of Lincoln, have developed their own fully equipped maintenance shops.

Insufficient data about maintenance costs was provided by state and local users to support any conclusions.

State Demographic and Growth Factors

The economic and demographic environment of Nebraska is a source of statistical data and future trends, which may be valuable in planning and design. The information below may be used in conjunction with user surveys and interviews to forecast future demand levels. The Department of Economic Development report "Nebraska's Economic Performance, 1998" (July 1999) contains a succinct overview of various economic and population parameters:

Population Indicators

The U.S. Census Bureau estimated a 1998 population at 1,662,719 as compared to a 1,578,417 in 1990—a modest increase of 5.3% over eight years. Growth over the entire period from 1950 to 2000 has been about 0.5% per year. Current projections call for this rate of growth to be sustained, yielding a total population of 1,892,000 by 2020.

Population density ranges all the way from 1.06 per square mile in Cherry County to 1,258 per square mile in Douglas. Only 32 communities in the state have more than 5,000 residents.

Eighty percent (80%) of the total population growth occurred in three metropolitan areas: Douglas (Omaha), 6.6%; Lancaster (Lincoln), 10.3%; and Sarpy, 18%. Adjacent counties also experienced significant percentage growth, with Cass at 14.9% and Washington at 12.4%.

Of Nebraska's 93 counties, 39 experienced increased populations between 1990 and 1998.

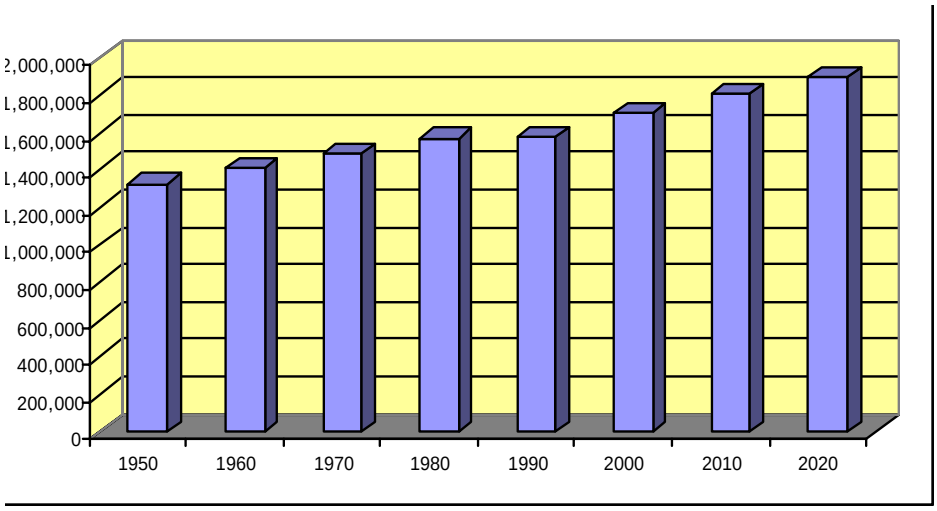


Figure 13: Population Projection

Economic Indicators

Nebraska unemployment rates averaged 2.7% in 1998, among the lowest in the nation and well below the national average of 4.5%.

- The number of non-farm wage and salary jobs increased by 2.3% from 1997 to 875,300. Service sector jobs grew by 3.6% to 237,800.
- Total personal income rose by 5.2% to $41.2 billion, and Nebraska's per capita annual income increased by 4.8% to $24,754.
- The Bureau of Business Research at the University of Nebraska-Lincoln estimates non-farm employment growth at 1.7-2.0% annually through 2001 and non-farm personal income growth at 6.2-6.5% during the same period due to expected upward wage pressure due to job growth (and low unemployment rates).

These factors taken together validate the assumption of continued steady population growth rate statewide, with a higher growth in urban areas.

Nebraska Law Enforcement Statistics and Trends

Law enforcement employment data show increases in both law enforcement and corrections personnel. The exception is the Nebraska State Patrol, which has lost officers over the last decade. Figure 14 below summarizes a few of these trends.

Category	Period	Avg. Per Year
Police	1991-1998	.92%
Corrections	1991-1998	1.79%
Sheriffs Departments All Employees Sworn Officers	1992-1998	 3.30% 3.66%
City Law Enforcement, Cities >5,000 All Employees Sworn Officers	1992-1998	 4.47% 4.16%
City Law Enforcement, Cities <5,000 All Employees Sworn Officers	1993-1998	 <.01% <.01%
Nebraska State Patrol All Employees Sworn Officers	1992-1998	 0.63% (0.60)%

Figure 14: Growth in Law Enforcement Officers in the 1990s

For purposes of the *Wireless Communications Plan for Nebraska*, several law enforcement statistics may be useful indicators of trends to supplement the user survey data.

- The overall crime rate in Nebraska per 100,000 increased from 4,213 in 1990 to 4,437 in 1996—a hike of .87% a year. The rate declined in the next two years to 4,405 in 1998, lowering the yearly rate for the decade to .56%. These trends mirror the direction of changes at the national level.
- Violent crime rates per 100,000 population, however, increased significantly from 330 in 1990 to 435 in 1996, which translates to 4.71% a year.
- During the same period, the combined federal-state prisoners in Nebraska per 10,000 population increased from 15.2 in 1990 to 19.9 in 1996. Again, this is an increase of 4.59%—not surprisingly, very close to the violent crime rate.
- Corresponding total prisoner *counts* under the jurisdiction of Nebraska correctional authorities increased from about 2,400 in 1990 to 3,400 in 1998—an increase of 3.86% a year.

Nebraska's Regulatory Climate

Laws and regulations establish key parameters with which this Plan must comply. Provided below are several matters that bear upon the Plan and implementation.

LB 446 Established the Policy Framework for This Study

The 1999 Legislature enacted LB 446, the Nebraska Public Safety Wireless Communications System Act, to address significant deficiencies in the public safety radio communications systems. The Legislative findings in Section 2 of LB 446 bear directly on the needs assessment, implementation plan, request for procurement and selection of a system vendor.

> Section 2(6) Investment in the public safety communication infrastructure is required to ensure the effectiveness of Nebraska's public safety agencies. Since the maintenance of public safety is a paramount concern but the cost of purchasing and operating multiple systems is prohibitive, it is imperative that local and state public safety agencies cooperate in their efforts…
>
> Section 2(7) A statewide seamless communications system should balance the need for multiple simultaneous users while maintaining autonomy for the internal use of individual agencies. The objectives of such a system should include maximizing resources and reducing duplication among public safety agencies as well as encouraging cooperation, coordination, consolidation, sharing, and partnerships between public agencies and private entities…"

In addition, Section 5 provides specific guidance for assessing the needs of public safety agencies:

> Section5 (2)…Needs assessment shall focus on maximizing available resources and minimizing duplication to facilitate the provision of seamless statewide public safety services. The implementation plan shall provide for the leasing, when feasible, of existing facilities, tower space, and equipment shelters owned by public or private entities.
>
> Section 5 (5) The division, with approval of the board, shall (a) hire an independent consultant to assist in developing the implementation plan and request for procurement and (b) select a system vendor pursuant to a competitive bidding process. The division and board may also contract with any private or public entities or political subdivisions to assist in developing the implementation plan.

Section 8(2)(e) provides that upon installation of the system infrastructure, the board shall have a continuing duty to:

> Coordinate communication strategy with other public and private entities, including political subdivisions, when feasible";

Taken as a whole it is apparent that the Legislature sought to obtain a comprehensive assessment of public safety needs and to utilize the broadest range of resources to

obtain the most robust, cost effective and efficient public safety communications system for Nebraska.

The state Division of Communications (DOC) has authority under ss. 81-1120.19 to purchase or lease communications facilities, services, and channels. Under this authority, DOC already leases many of the voice and data lines used by all state and some local agencies. Logically, any voice or data lines needed to support a state radio system could be and most likely would be supplied by DOC via its network contracts.

An important element of planning and implementation, consistent with LB 446, would be to cast the telecommunications resource net as widely as possible–in a technologically and ownership neutral manner--to ensure that the most robust and cost effective public safety communications system results. Potential provider participants must necessarily evaluate their legal authority to provide services and facilities and to team with potential prime vendors.

Mobile Radio and Wireless Telecommunications Services Are Not Regulated by the Nebraska Public Service Commission (NPSC)

Article 8 Telecommunications Section 86-808 (1) specifies that certain communications services are not regulated by the NPSC:

> (1) Except as provided in subsection (2) of this section, the commission shall not regulate the following:
>
> (a) One way broadcast or cable television transmission of television and radio signals; and
>
> **(b) Mobile radio services, radio paging services, and wireless telecommunications service.**[12]

NPSC Lacks Authority over Lease of Dark Fiber by Entities Other Than ILECs[13]

Regarding the current status of various issues relating to the potential role of public power entities, which are political subdivisions of the State, to participate in the public safety telecommunications planning, NPSC's Order C-2044/PI-27 (January 11, 2000) included the following findings:

[12] Emphasis added.

[13] Incumbent Local Exchange Carriers

> …the Commission…does not have jurisdiction over the leasing of dark fiber by entities other than ILECs. To the extent that this Commission has previously ruled that the leasing of dark fiber was a telecommunications service, the Commission hereby modifies said ruling. The Commission is of the opinion and finds that the leasing of dark fiber alone, without more, is not a telecommunications service as defined by statute. As such, the Commission will only regulate the leasing of dark fiber to the extent required by the FCC when it is considered an unbundled network element of an incumbent local exchange carrier.
>
> Nonetheless, the question of whether the leasing of dark fiber is a service not regulated by this Commission does not address the issue of whether it is legal or appropriate for dark fiber to be offered by a political subdivision of the state… this order shall in no way be interpreted as permission for, or an endorsement of, the offering of dark fiber for lease by political subdivisions.
>
> ORDER. IT IS THEREFORE ORDERED by the Nebraska Public Service Commission that the leasing of dark fiber shall only be regulated to the extent required by the FCC. This FCC directive extends only to the regulation of dark fiber offered by ILECs as an unbundled network element. IT IS FURTHER ORDERED that this shall in no way be interpreted as permission for, or an endorsement of, the offering of dark fiber by political subdivisions.

Public Power Districts As Potential Providers, Partners or Users of Public Safety Wireless Communications Systems and Public Safety Emergency Responders

The various electric power providers have existing radio, tower, digital microwave, wireless and fiber facilities used for the conduct of their business. Obviously, the electric power transmission and distribution facilities are important infrastructure elements that are not only impacted by natural disasters and other emergency circumstances (floods, fires, storms, sabotage) but also represent important infrastructure/essential services to maintain and restore for the public safety and welfare of Nebraskans. The State's RFP for the Public Safety Wireless Communications System Design Study: references an earlier consultant radio study in 1995 that assessed public safety wireless communications. That study specifically included a proposed partnership with Nebraska Public Power District (NPPD) for a shared system design.

As political subdivisions of the State, the public power entities appear to offer opportunities to participate in the public safety communications plan as partners, users, or providers of facilities. The direction in LB 446 appears to encourage incorporation,

utilization, and integration of these communication resources in the Wireless Communications Plan.

Wireless Resources in Nebraska

Below is a brief recap of the wireless technology resource pool potentially available in Nebraska, in addition to the existing systems discussed earlier.

Availability of Radio Frequencies

The chart at the beginning of this section introduces the six frequency bands used for public safety: VHF low-band (30-70 MHz), VHF high-band (150-170 MHz), 220 MHz band, UHF (450-470 MHz), and the 700 MHz band and 800 MHz bands. A more detailed treatment of the ways these frequencies are used in Nebraska appears below. (Technical characteristics of the different frequency bands are discussed in Section 4.)

- VHF low-band: State and local entities in Nebraska are significant users of this spectral region. County sheriffs, fire, police, emergency medical services and other local agencies employ frequencies in the 39 MHz segment; the State Patrol uses the 42 MHz segment, and the Department of Roads the 47 MHz segment. Some of these frequencies have been continuously licensed for over 50 years.

  Effective propagation of a radio signal decreases as the radio frequency increases. Thus low-band systems cover the widest footprint area from their transmitter location and require the fewest towers to cover a large territory. However, low-band is subject to other inherent natural drawbacks.[14] As a result, regulators have tended to neglect offerings in this band in recent years. Trunking, for example, which is now authorized for other bands, is still not permitted for low-band.

  Similarly, manufacturers have neglected or dropped their low-band equipment offerings. Replacement parts and service availability are dwindling to critically low points. Low-band users are generally limited to repairing rather than replacing existing equipment, often resorting to salvaged parts. Nevertheless, hundreds of agencies at all levels of government in Nebraska make good use of the low-band spectrum for day-to-day operations, and at some point regulators and manufacturers may 'rediscover' low-band.

- VHF high-band: State and local agencies have made good use of this frequency band. Some agencies employ high-band for field tactical communications using hand-held radios in combination with vehicular repeaters. Some local

Trunking: A scheme borrowed from the telephone industry, in which a group of radio channels is seamlessly shared by all users, dynamically allocated in response to demand by microprocessor control systems. Trunking packs scarce channels much more intensively, and is now required for all systems that have more than five channels (10 frequency pairs)

[14] Such as atmospheric interference and the tendency of signals at this frequency to bounce off the ionosphere, particularly during sunspot cycles which last for several years. In Nebraska, the most common example of this phenomenon, which is called "skip," is the reception of radio traffic from Mexico.

agencies employ high-band systems using repeaters as their main area-wide communication system, having abandoned low-band because of its drawbacks.

Changes in FCC regulations over the past decade have had a significant effect on this band. Trunking is now permitted for VHF, as is the opportunity to increase channel availability through narrow banding. Manufacturers have generally welcomed these new opportunities by offering an abundance of radio and ancillary products for VHF high-band, ranging from the simple and inexpensive to the complex and costly.

Narrowbanding: Another scheme for making more intensive use of the radio frequency spectrum. Channels are subdivided into a fraction of their traditional size. Usefulness is not impaired, because new technologies makes it possible to transmit ever-larger amounts of information in a given amount of bandwidth. Similarly, ordinary telephone lines can now connect to the Internet at 56 kbps, while only a few years ago the limit was 1.2 kbps or even less.

High-end features now available include digital transmission and digital encryption. Because the Treasury and Justice Departments of the Federal Government use huge amounts of VHF high-band and high-end VHF equipment, the ready and continuing supply of equipment for other levels of government is virtually certain.

Research conducted for this study indicates good availability of potentially licensable VHF frequencies for statewide, regional and local use within Nebraska. High band propagation characteristics are well suited to Nebraska's terrain, although the footprint of coverage from a tower transmitter is less than low-band. Building penetration is also good.

- 220 MHz: According to Nebraska Public Power District communications experts, some rural power districts are using, or contemplating the use of, or experimenting with 220 MHz radio systems. No other users of 220 MHz were discovered during this study.

- UHF: Good use has also been made of this frequency band by state and local agencies One common application is to install mobile UHF repeaters in public safety vehicles. The repeaters are able to translate from another band, such as low-band, and UHF; users then use their UHF portables in combination with a VHF primary system. The most typical use of this technology is in tactical law enforcement agencies and functions, where it provides vehicle to vehicle and portable to portable communications within a somewhat limited[15] range. The State Patrol is a leading example of this arrangement.

  Other agencies employ UHF as their main area-wide communication system, having abandoned low-band because of its drawbacks. Buffalo County public safety agencies have a highly integrated system using primarily UHF. Many hospitals utilize the FCC-designated "medical" channels for incoming ambulance and helicopter communications. Building penetration is generally good with UHF, while its range over open terrain is less than high-band but greater than 800 MHz.

[15] The range is more limited because most portable radios operate at a much lower power level than mobiles, not because of any inherent limitation in UHF.

- 700 MHz: A total of 24 MHz of radio spectrum in the 700 Mhz band was initially reallocated by the FCC in 1998 from use by television broadcasters to land mobile radio. Late in 2000, the FCC established a "band plan" specifying how this total allocation will be used. Under this band plan, 764-776 Mhz, formerly television channels 63-64, will be used for base to mobile communications, and 794-806 MHz, formerly channels 68 and 69, will be used for mobile to base communications. Provision is made for narrowband and wideband radio channels, and for various types of users (licensees).

  The FCC has now determined that each state will be able to apply for up to 2.4 MHz within the new allocation.

  > The Commission has long encouraged public safety agencies to develop wide-area multi-agency trunked public safety radio systems and the 700 MHz band public safety allocation offers a unique opportunity to facilitate the development of these systems. Under this approach, states will have limitless possibilities to apply their unique expertise and knowledge to best use the radio spectrum to meet the public safety needs of their citizens.[16]

  States can file applications for licensure until December 31, 2001, and there will be an extended time period for making use of the frequencies, since some are still in use by the broadcasters from whom they are being reallocated.

  In the same order, the FCC has also established measures to promote interoperability on public safety channels below 512 MHz. Five channels are designated in the 150-174 MHz (VHF high) band and four channels in the 450-512 MHz (UHF) band for public safety mutual aid purposes.

  Propagation characteristics are thought to be most closely similar to the 800 MHz, but the use of this band will be somewhat experimental for some time until its characteristics become widely understood. Equipment manufacturers are expressly encouraged by the FCC to produce radios and related systems capable of operating in both the 700 MHz and 800 MHz bands. The leading manufacturers of radio equipment are developing such systems, but these will not be widely available for a few years. The most recent indications are that states will use 700 MHz as a supplement to 800 MHz systems already in place, using these dual band radios, where 800 MHz channels are crowded. As noted

[16] FCC 00-348, Third Report and Order, The Development of Operational, Technical and Spectrum Requirements for Meeting Federal, State and Local Public Safety Agency Communications Requirements Through the Year 2010, Released October 10, 2000.

below, this consideration does not appear to apply in Nebraska, where 800 MHz frequencies are available.

- 800 MHz (NPSPAC): 800 MHz is the primary frequency band selected by Sarpy and Lancaster County public safety agencies. The Seward Police Department is using 800 MHz from a commercial provider, and there is a plan for all public safety agencies in the county to unify their systems in this band. Douglas and Buffalo Counties use 800 for mobile data. Survey data indicates that 800 MHz is also in use by the Garden and York County Sheriffs Departments and the Norfolk and Auburn Police. Major radio equipment manufacturers offer comprehensive products for this band, but implementation is highly vendor specific because equipment from different manufacturers is proprietary and mutually incompatible.

  When 800 MHz was initially authorized for use, the FCC permitted state and local governments to reserve channels provided that they developed comprehensive plans for their use. Nebraska developed and first filed a National Public Safety Planning Advisory Committee (NPSPAC) Plan in 1991. The plan, now in its fourth revision, provides for a total of 168 channels (pairs of frequencies) in the 800 MHz band. Fifteen of these channels are allocated for true statewide use, while the balance is distributed for local and regional use.

Availability of Towers

In addition to the tower complement used by state level agencies addressed earlier in this report (see Section 2, Figure 5), county and local agencies and public power districts lease, own, occupy, and operate antenna support structures in connection with their own wireless communications requirements. These structures may be either towers erected for the purpose or tall buildings, water tanks, and similar structures suitable for mounting communications antennas. It is common to observe the main city or county buildings in a town square adorned with multiple land mobile radio antenna installations.

The Division of Communications also provided this study with a database of nearly 3,000 individual towers located in Nebraska. This database is believed to have been current in 1995, based on publicly available tower licensing information. It includes all the government-owned structures discussed above, plus towers owned by telecommunications common carriers, broadcasters, commercial radio providers, public power districts, and many other private owners. With the exception of the rapid infrastructure development that has taken place for cellular and PCS services, this

database is considered not to have changed significantly.[17] Any of these tower sites may potentially be utilized in implementing radio systems for the public safety sector.

Service and Equipment Providers

- Radio Vendors: Nebraska, like other states, is supplied with local radio equipment dealers and maintenance providers. However, contacting these providers was outside the scope of this study. State and local agencies are key customers for the major radio manufacturers and their local representatives. No data was supplied to the consultants regarding the levels of annual radio equipment and replacement expenditures.

- Public Power Districts: Interoperability between PPDs and public safety agencies becomes critical during emergencies in which electric transmission and distribution lines and related customers are affected by outages. Electric power utilities in Nebraska are in the form of public power districts (PPDs). The two largest PPDs in Nebraska are the Omaha PPD and the Nebraska PPD. OPPD serves an area including not only the Omaha metropolitan area but also counties from the southern border to the north. NPPD covers a large area in the central portion of the state. Both operate regional-scale dispatched land mobile radio systems for their own internal communications purposes, such as power line repair and construction and retail customer service.

  OPPD has upgraded over a period of years to a modern 800 MHz radio system. NPPD, however, operates an older VHF low-band system that is in need of replacement or upgrade. NPPD has a continuing interest in participating in a State of Nebraska radio system when one emerges, and when funding becomes available. OPPD is generally willing to partner with public service agencies if that becomes feasible, although its own system already meets its internal needs.

- Telecommunications Common Carriers. Telephony services are important component s of public safety communications networks. One obvious way this is true is that radio users at times make connections through their communications centers to the public switched telephone. In emergencies, wireline and wireless communications paths also offer redundancy; if one becomes unavailable, the other may still be usable.

  In addition, the majority of the public safety agencies interviewed for this study also use cellular telephone service on a routine basis. Nebraska is relatively well served with cellular and PCS providers, which cover much of the state's area. DOC maintains a master contract for analog cellular services, charging a flat price

[17] It is intended that the final edition of this Plan will include additional relevant tower data provided by the Omaha Public Power District, and information that has been requested from the Nebraska Public Power District and various cellular telecommunications.

per minute to state agencies that subscribe. Cellular is most useful for routine and administrative matters, since in emergency situations it quickly becomes too busy to carry emergency traffic. However, it has its place in the mixture of communications paths used by public safety agencies.

Finally, dedicated wireline services play a role in radio networking, just as they do in telephone, computer and video networks. Leased services from Nebraska's common carriers, including local exchange carriers, interexchange carriers, wireless and PCS carriers and others, can potentially carry radio traffic between tower sites, between tower sites and network hubs or nodes, between towers and base stations or dispatch centers, and between dispatch centers. Often, radio systems deliberately use both landlines and radio pathways for redundancy.

- Division of Communications: DOC acts as an internal aggregator of the needs of individual state agencies and universities, thereby obtaining the best rates available from the regulated common carriers. DOC master contracts cover significant landline capacity from commercial telecommunications; it is the largest single customer, for example, of Alltel's operations in this state.

  Under the TINA[18] project mentioned earlier in this Plan, DOC's mission to aggregate bandwidth and lease common carrier services will be broadened to encompass many local government agencies around the state. DOC plans to develop a Request for Proposals to select a prime contractor and billing service for network services in the coming year. Rates for dedicated bandwidth services are anticipated to be significantly lower than current costs. This contract should have a positive effect on the public safety wireless community by bringing connectivity at a reasonable rate to potentially nearly any community in the state.

The Environment Outside Nebraska

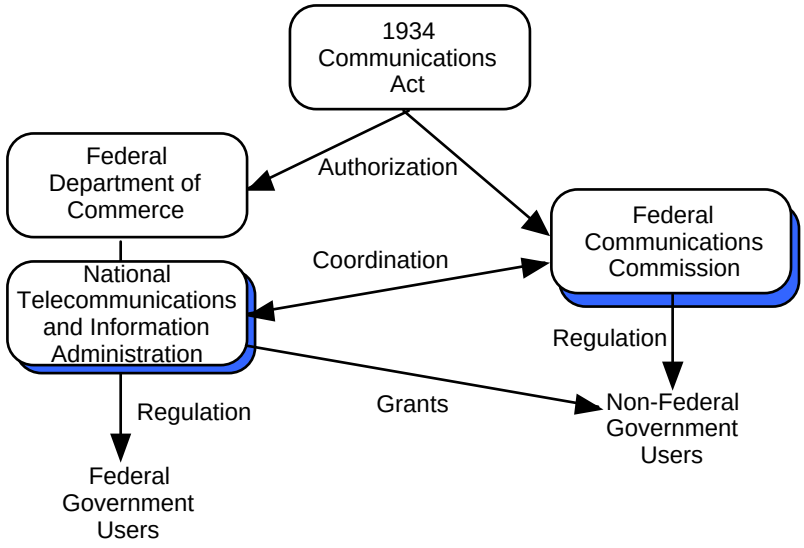
The Federal government is a source of information and possible funding for state and joint state/federal initiatives, as well as being the primary regulatory agency for wireless communications. Federal government agencies, notably the bureaus of the Departments of Interior, Justice, and Treasury, also have interoperability needs with Nebraska State and local entities. In addition, Nebraska borders on six adjacent states: South Dakota, Iowa, Missouri, Kansas, Colorado, and Wyoming. Each of these states has taken its own path to public safety wireless communications without particular regard to interoperability with Nebraska, although such is in the vital interest of each. Finally, the recent actions of a few additional states serve as useful points of comparison.

[18] Telecommunications Infrastructure Needs Assessment

Federal Wireless Planning Environment

The Federal Communications Commission (FCC) has been involved in a number of major decisions and underlying policy issues in recent years. Many of these issues primarily affect commercial providers of cellular and PCS services and mobile radio services. These issues are only indirectly related to Nebraska's situation, since public safety agencies either use very few of these services or use them as supplements to their dedicated land mobile radio systems.

Figure 15: Roles of Federal Regulatory Agencies



The two newest public safety allocations in the radio spectrum, in the 220 MHz and 700 MHz bands, were mentioned earlier. Because these were reallocations from earlier authorizations, there were long negotiations and challenges in making the required transitions. People who watched the aftereffects of the Telecommunications Act of 1996 will have observed the difficulties in auctioning off frequencies for non-government users.

More relevant is the attempt to mandate migration to narrowbanding of VHF (high band) channels. The FCC proposed to make this migration mandatory, and force existing users to systematically convert all their systems by a specified date. This proposal has not so far been adopted. Instead, there is a requirement that all radio manufacturers must by 2000 produce only equipment that is narrowband *capable*. In addition, the FCC has stated that it will no restrict *new* licenses for wideband VHF channels. Many observers think that the mandated conversion to all narrowband will eventually be adopted as well.

Whereas the FCC governs radio spectrum allocations for commercial, state and local entities, spectrum for use by Federal government agencies is allocated by the National Telecommunications and Information Administration (NTIA). NTIA has mandated that VHF (high band) channels used by Federal agencies must be converted from wideband to narrowband by the year 2005. This action does not directly affect Nebraska, except insofar as the mandate applies to federal agencies operating in the state, including Native American Reservations.

Of potentially more significance is that the Federal Departments of Justice, Treasury, and others will be overhauling their mobile radio systems, and they are keenly interested in asset consolidation, asset sharing with states, and interoperability with

state law enforcement entities. Excess system capacity being intentionally built into these consolidated Federal systems will be made selectively available to state agencies.

Wireless Activities in Other States

The summaries below mention very briefly the current status of public safety radio in the six states surrounding Nebraska, plus a few other states who have recently enacted major radio initiatives.

Colorado: When statewide installation is complete, Colorado will use an 800 MHz trunked system for all public safety and government radio. Implementation has been proceeding since 1991. Colorado officials predict that the system will eventually include 120 radio sites, each supporting five channels. There will be a total of five consolidated dispatch centers serving the estimated 10,000 mobile and portable users. It is intended to provide an average of 95% coverage when completed. Oversight and maintenance are the responsibility of the Telecommunications Services Division of the Department of General Services. No significant use of VHF frequencies will remain after full implementation.

Florida: The State of Florida, after some years of difficulty and overspending in attempting to replace their radio systems by traditional means, have recently signed a partnership agreement with a leading vendor. This agreement will basically place the state's current radio assets under the control of the vendor, who will lease service to agencies in increments as needed. It remains to be seen how successful this innovative arrangement will be, but clearly the radio marketplace is now willing to consider non-traditional business opportunities.

Iowa: Iowa has progressively implemented a VHF high-band system since the early 1970s for use by all law enforcement agencies at the city, county, state, and the federal levels. The system features 28 two-repeater sites using six frequency pairs checker-boarded around the state. The 300 Watt wideband analog repeaters use a different squelch tone for each site to minimize skip and co-channel interference. In addition, each county has simplex capability on 155.370 MHz. UHF vehicular repeaters provide cross-band connectivity to the main VHF system. Mobile data is desired by law enforcement but not implemented at VHF. Some UHF and 800 MHz system deployments also exist around the state serving larger cities. The current system has the capability of converting to digital, but the state does not expect to make this conversion in the near future, since it would force local users to upgrade as well.

Five of Iowa's sites (Glenwood, Atlantic, Newmarket, Dennison, Moorhead, and Merrill) could affect Nebraska users of VHF, offering the possibility of interoperability as well. Iowa has two communications centers near the Nebraska border as well, one in the north and one in the south. Currently, the primary form of interoperability with Nebraska jurisdictions is by telephone.

Kansas: Kansas is implementing a statewide conventional 800 MHz system for use initially by state agencies, with designed excess capacity to accommodate local agencies.

Trunking and mobile data are future considerations. The system is reportedly about 75% complete after 4 years; implementation is rolling out from east to west as funding is appropriated. The Department of Transportation and the State Patrol are the primary users, with most state agencies on as well as ambulance services already aboard. Their implementation is aimed at covering the whole state. Remaining local agencies primarily use low-band; there is no significant use of VHF in the state.

Kentucky: Kentucky has recently awarded a contract for a statewide narrowband Project 25 system, which will be installed by the end of 2001. The system is not trunked, and will serve State Police on two digital channels and one analog channel. VHF is a good frequency band selection for this state because of the mountainous terrain and heavy forestation. The digital channels will be used for internal communications by 1,250 officers, and the analog channel will provide connectivity with non-digital users. A total of 97 tower sites are being installed.

Missouri: The State of Missouri has no statewide systems; even the State Patrol operates on a regional basis. They use primarily low-band, for which the infrastructure has been recently replaced, and supplement it with a VHF channel that is licensed across the state. VHF equipment in use is generally older, and there is no deployment of advanced functionality.

Ohio: This state is developing a well-publicized multi-agency shared statewide radio system, scheduled for completion in 2003. It will serve most state agencies from a single shared system managed and dispatched centrally, replacing many separate and aging systems. Connectivity via the State's SONET network ensures adequate backbone capacity and data-handling capability. In the planning process since 1987, the system as completed is expected to cost $271million to serve about 10,000 users from 200 sites (

South Dakota: South Dakota currently has statewide VHF capability for certain state agencies. A recently concluded a study which recommended enhancing its existing four channel statewide VHF system by adding channel capacity and implementing narrowbanding, trunking, and selective application of digital modulation.

Virginia: A shared system has been installed in Virginia serving an Army Defense Supply Center, Army Fort Lee, a Navy facility, and at least on nearby city. This system is being cited as the first federal-local public safety system in the country. It will accommodate both UHF and 800 MHz frequency bands, and over 4,000 users

Wisconsin: Wisconsin's Department of Transportation (including both Highways and State Patrol) is planning to migrate to a trunked statewide VHF system using shared military frequencies. They selected VHF both because their existing systems are largely in this band, and because VHF provides greater coverage per site than 800 MHz. Because it is a shared system with Federal agencies, it is subject to the mandated narrowband and Project 25 (digital) requirements. The system is now under testing.

Wyoming: Wyoming Highway Patrol and Highway Engineering, both part of the Department of Transportation, use VHF wideband frequencies. Local governments also use VHF, and share the mutual aid frequencies with state agencies. EMS agencies have somewhat fragmented statewide system. The state VHF sites are tied together with dedicated microwave. Mutual aid is deployed as a single, simplex, open squelch frequency. Typical systems date from the 1970s and provide no trunking or other advanced functionality. There is heavy use of cellular services for administrative purposes within the somewhat limited areas they currently serve. Although they have made some efforts to do preliminary design and costing of an 800 MHz system, there has been no commitment to proceed.

The Wireless Marketplace

Standards: sets of precisely-stated and widely accepted definitions that are useful as models for designing or implementing information technology systems.

Standards may be
- technical, *e.g.*, specifying how devices communicate with each other or how they are built,
- procedural, such as common training or operational methods, or
- performance, *e.g.*, criteria for established measurement.

Three major manufacturers dominate the radio marketplace: E.F. Johnson, ComNet Ericsson, and Motorola. These manufacturers are the traditional producers of low-band, VHF, UHF and 800 MHz systems and equipment. A number of second- and third-tier companies also provide less than full lines of radios and related accessories. Another industry segment provides antennas, towers, and transmission line related accessories through a number of manufacturers.

In every area of technology today, a difficult and significant task involves regulators, manufacturers and users in the effort to establish standards. The value of standards is that they promote interoperability—the ability of different pieces of equipment and their users to nevertheless work together. In the wireless communications (and land mobile radio) industries, there have been many standards-setting activities carried out over the years. As new technologies emerge, standards must be constantly revised and updated. Most recent is the establishment of a standard known as Project 25.

The radio industry is embroiled in a debate between competing technologies in the 800 MHz frequency band. In the radio technology war, however, no clear winner has yet emerged in the land mobile radio arena. The competing technologies, from Ericsson and Motorola persist side-by-side in the marketplace. Both are highly effective and viable, but the digital over-the-air formats are nevertheless incompatible.[19]

Project 25 is a technical standard for digital, trunked public safety systems. It was propounded to resolve the incompatibility issues now plaguing users of 800 MHz, and to ensure a competitive marketplace. However, to date only Motorola has successfully fielded a full product line of Project 25-compliant radios. It is expected that other manufacturers are planning to enter this marketplace or add to their product lines to provide an alternative to Motorola for Project 25 products. At the moment, this competition is mostly hypothetical.

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[19] This scenario is played out daily in Nebraska, where the 800 MHz system in Sarpy County is from Motorola, and the 800 MHz system in Lancaster County is from Ericsson. When users are communicating in digital mode, they are unable to communicate with each other. State Patrol and other agency officials in the area can't communicate with either system.